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AOIPS WATER RESOURCES DATA
MANAGEMENT SYSTEM

Peter Van Wie

Presented at

Director's Scientific Seminar
Earth Resources Survey:
Technology Transfer and System
Concept Development

February 1977

GODDARD SPACE FLIGHT CENTER
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ABSTRACT

This publication contains the text and computer-generated displays used to demonstrate the AOIPS Water Resources Data Management System at the Goddard Space Flight Center Director's Scientific Seminar of December 2, 1976. AOIPS is the Atmospheric and Oceanographic Information Processing System.

This system was prepared by Earth Satellite Corporation for Goddard Space Flight Center under contract number NAS5-22894.

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GLOSSARY

AOIPS	Atmospheric and Oceanographic Information Processing System
CRT	Cathode ray tube
Geocoded	Geographically coded
Landsat	Land Observing Satellite (formerly ERTS)
MSS	Multispectral Scanner
NCIC	National Cartographic Information Center
SMS	Synchronous Meteorological Satellite
VHRR	Very High Resolution Radiometer
WMO	World Meteorological Organization

AOIPS WATER RESOURCES DATA MANAGEMENT SYSTEM

BACKGROUND

A Water Resources Data Management System has been developed at Goddard Space Flight Center to assist hydrologists in analyzing the physical processes occurring in watersheds. The system is designed to alleviate some of the problems encountered while investigating the complex interrelationships of variables such as:

- Land-cover type
- Topography
- Precipitation
- Snow melt
- Surface runoff
- Evapotranspiration
- Streamflow rates

and other physical circumstances existing in a typical watershed. These variables are observed and measured through a variety of techniques which, in turn, present the hydrologist with a collection of dissimilar data types to work with. Conventional hydrology data sources include thematic maps, aerial photography and point-source measurements (streamflow, soil moisture, etc.). These data types differ in a number of ways, such as spatial resolution, cartographic projection, dimensionality and format (magnetic tape, photographic image, paper map, tabular listing, etc.). Since most investigators prefer to use all pertinent data, a problem exists. How can this collection of dissimilar data be organized and managed in a systematic and efficient manner so that the benefit of each data type is realized?

A number of new hydrological-data sources and data processing techniques have come into existence in recent years. Spaceborn remote sensing instruments on Landsat and Synchronous Meteorological Satellites are providing a vast amount of data which can supplement or replace conventional-data sources. The statistical techniques of multispectral classification applied to Landsat images can produce detailed land-cover information of enormous value in hydrological investigations. The ability to display and manipulate image data from satellite sensors, and to perform multispectral classification is currently available in interactive image

processing computers such as Goddard's Atmospheric and Oceanographic Information Processing System (AOIPS). The color video display (CRT) on AOIPS links the investigator to his data in a manner which allows his perceptual abilities to become part of the analysis process. Finally, the techniques of geographically coded spatial-information systems provide a mechanism for dealing with the complex data-organization problems previously mentioned.

The AOIPS Water Resources Data Management System was developed with the hope that it could address the many difficulties and opportunities presently in existence and provide a method of successfully working with the many conventional and novel data sources available. It was developed in parallel with a case study of the Bear River Watershed, an area northeast of the Great Salt Lake. The case study approach offers the advantage of testing and demonstrating the system in an operational environment. Figures 1 and 2 show the case study area in map and Landsat form respectively. This system is a prototype which should serve to test the concepts mentioned and suggest improvements and/or revisions in approach for use in more advanced, future data management systems.

INTRODUCTION

This demonstration will show an AOIPS application project in hydrology called the Water Resources Data Management System.

There are three key elements to this system:

First: The system is implemented on AOIPS so it has an interactive image processing capability and a color CRT to display results as they are obtained. The user is brought much closer to his data than with other types of systems. He can experiment, try different processing options, and see the results immediately.

The second key element is the Data Management capability built into the system software. Several very different types of data needed for hydrology investigations are accommodated by this Data Management System. The data types include:

- Landsat MSS imagery
- SMS VHRR imagery
- Digital topographic data
- Ground truth data such as basin maps, stream-flow records and temperature records.

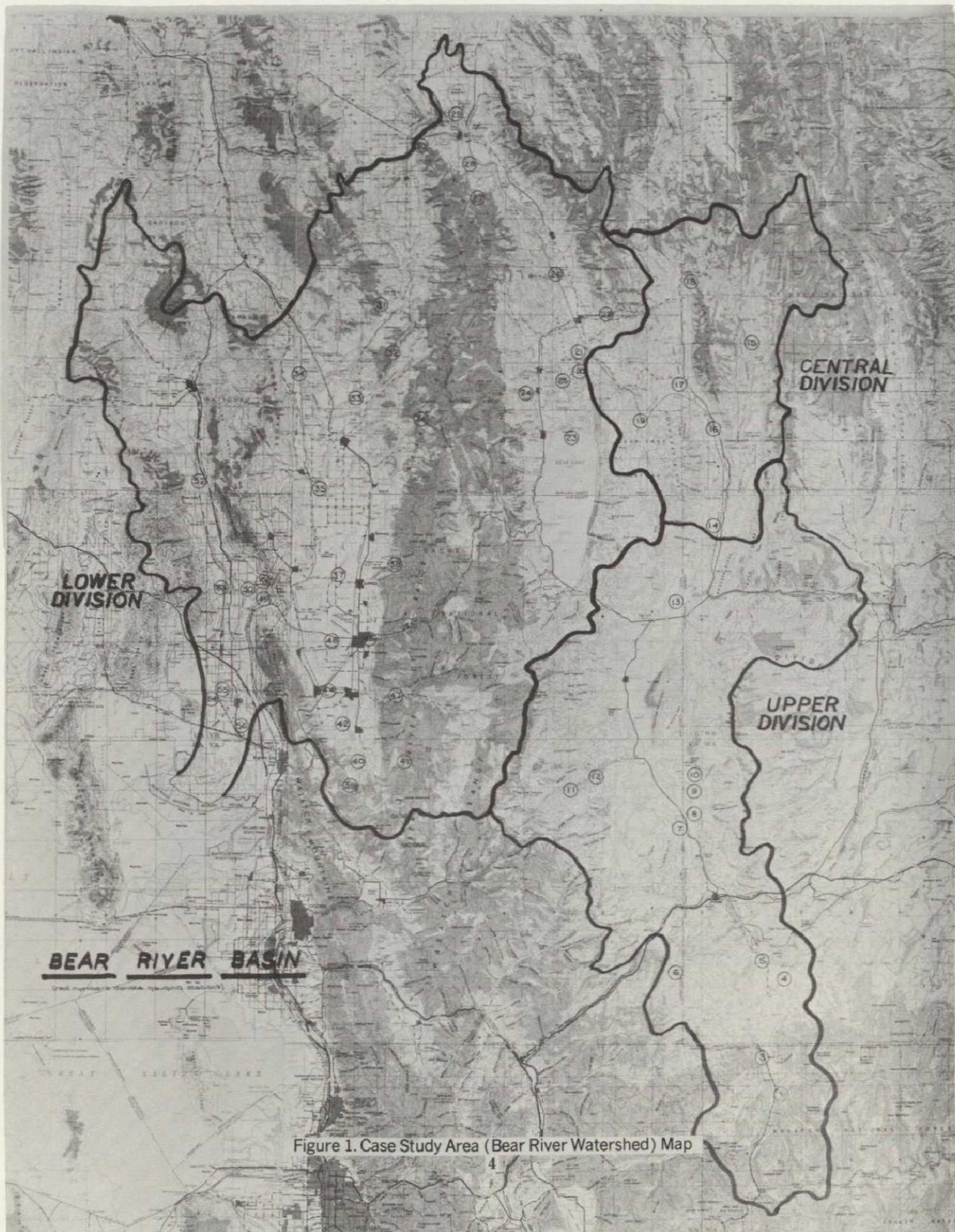
The Data Management System will also accept derived data such as:

- Landsat classification maps and
- precipitation maps from SMS data.

These data types have a common thread; they all relate to geographic locations. So the Data Management System operates on geographically coded "geocoded" data bases. The data bases are structured around 1-nautical mile cells or resolution elements covering the watershed under investigation.

An archive data base is used to store information which is constant over time - such as topographic data, basin maps and ground-cover classification maps. Daily data bases hold dynamic data such as precipitation maps and snow-cover maps.

The third and final element is the case study data. The Bear River watershed was selected as a case study area to demonstrate and test the system. The Bear River is located in Northern Utah with portions running into Idaho and Wyoming. The watershed covers an area of approximately one Landsat frame. Landsat, SMS and topographic data for the Bear River watershed have been processed by the Water Resources Data Management System.



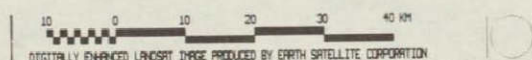


Figure 2. Landsat Image of Case Study Area

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CLASSIFIED LANDSAT DATA

This first display shows Bear Lake and a portion of the Bear River watershed. The Landsat data used to produce this display were sampled every 200 meters and then classified, using AOIPS, into four categories of land cover.

- (1) Water - shown as orange
- (2) Marsh - beige
- (3) Forest - blue and
- (4) Natural vegetation - yellow
- Unclassified areas were left blank.



Figure 3. Classified Landsat Data

WMO PROJECTION

To store these land-cover data in the data base, specifically the archive data base, they are aggregated into 1-nautical mile cells. These cells are arranged in the World Meteorological Organization (WMO) projection - which was selected as the map projection for the Data Management System. The dots shown superimposed on the Bear Lake image fall at the center of every fourth 1-mile WMO cell. The WMO axes are rotated relative to the image - the WMO horizontal axis runs from lower left to upper right.

A separate record exists in the data base for each 1-mile cell. A cell record holds all available data pertaining to that cell. For example, the percentage area for each ground-cover class in a cell is kept in the cell record.

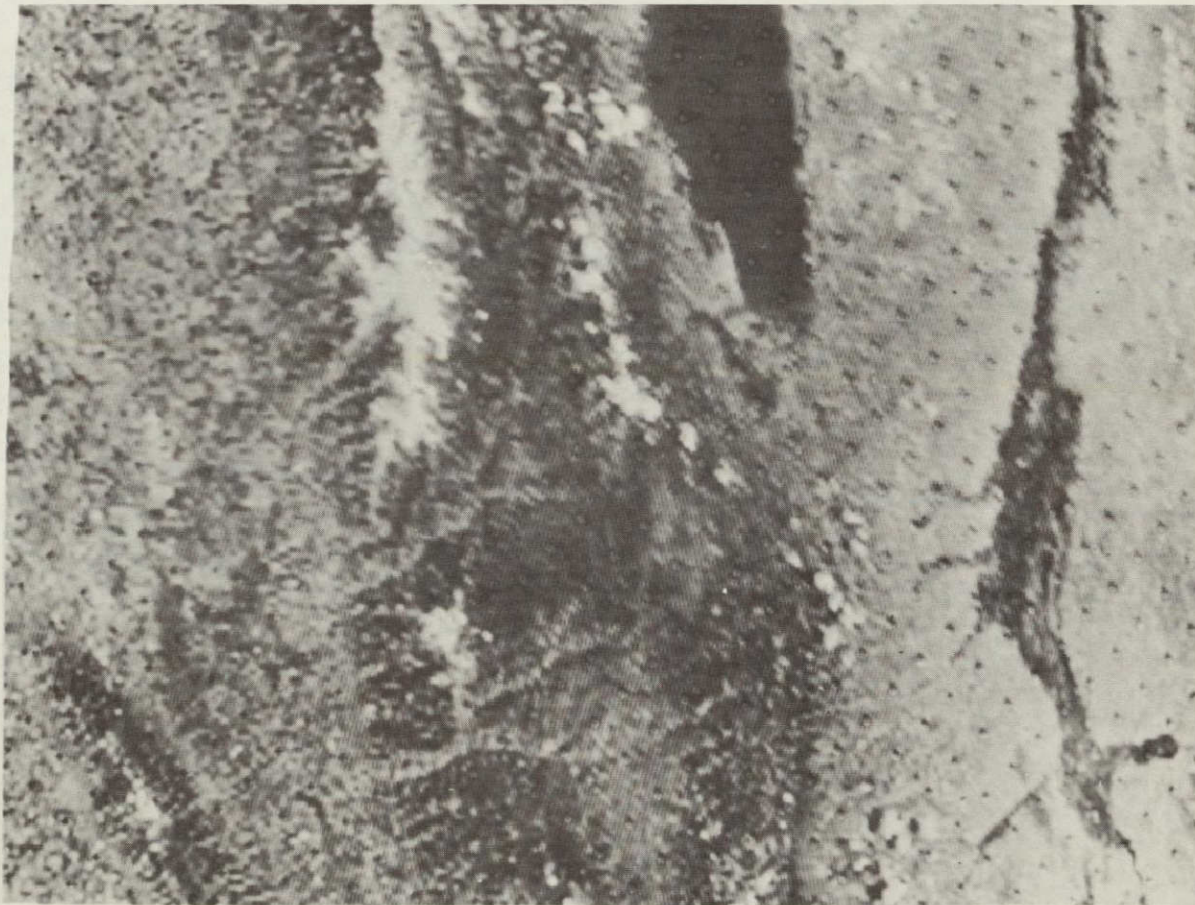


Figure 4. WMO Projection

AGGREGATED LANDSAT DATA

This display illustrates the cell data corresponding to the ground-cover map. Notice that the data are rotated - the WMO axes are now aligned with the CRT axes.

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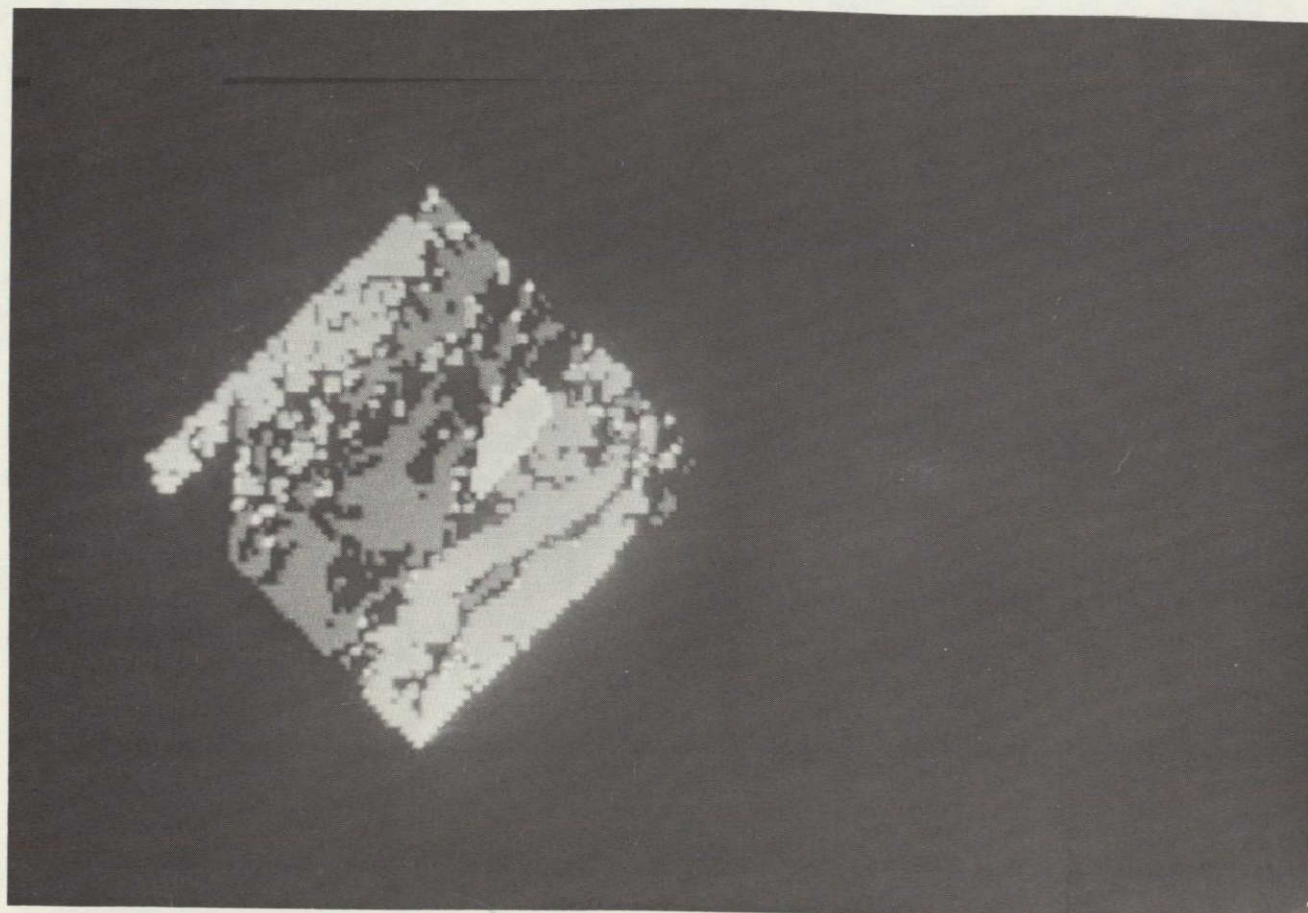


Figure 5. Aggregated Landsat Data

BASIN MAP

The data base also contains a basin map. Here the three subbasins are shown as blue, light blue and orange. The upper subbasin (in blue) is called the Lower Division. The lower subbasin (in orange) is the Upper Division. And the small subbasin (in light blue) on the right is the Central Division.

The data for this display were manually digitized off a paper map. Approximately 40 points were used to form polygons about the subbasins. The polygons were then transformed to cells and added to the data base. This allows us to access other cell data by subbasin, if we wish.

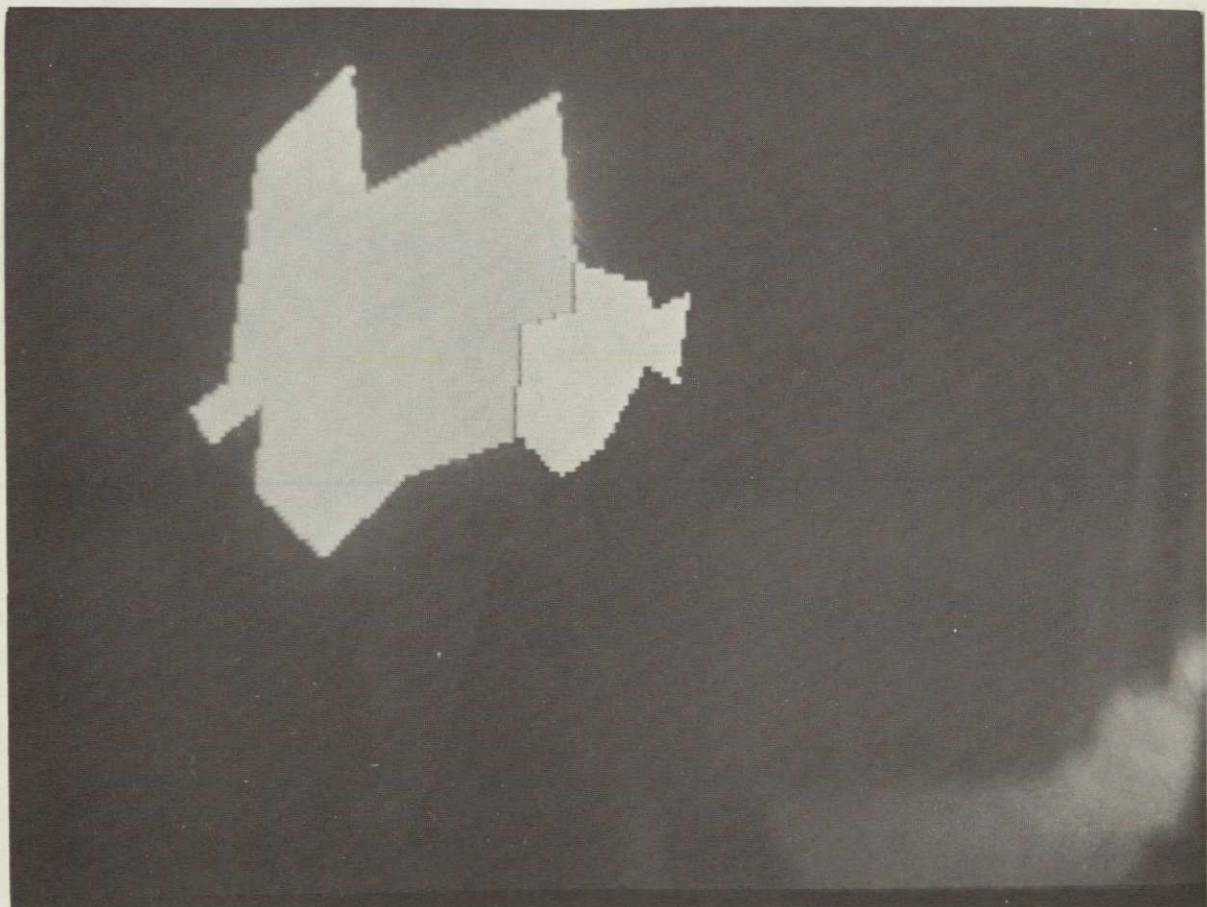


Figure 6. Basin Map

LANDSAT AND BASIN OVERLAY

The primary advantage of organizing data into a geocoded data base is that it allows us to see the relationship between different data types and to superimpose several data types in one display.

For example: all cells containing over 40 percent water cover are shown here in blue-green. Next, areas over 40 percent forest covered are shown in blue or pink. Finally, the basin map is superimposed on the water and forest maps. The subbasins are different intensities of orange.

The significance of this display is that any theme represented in the data base can be displayed in this type of overlay.

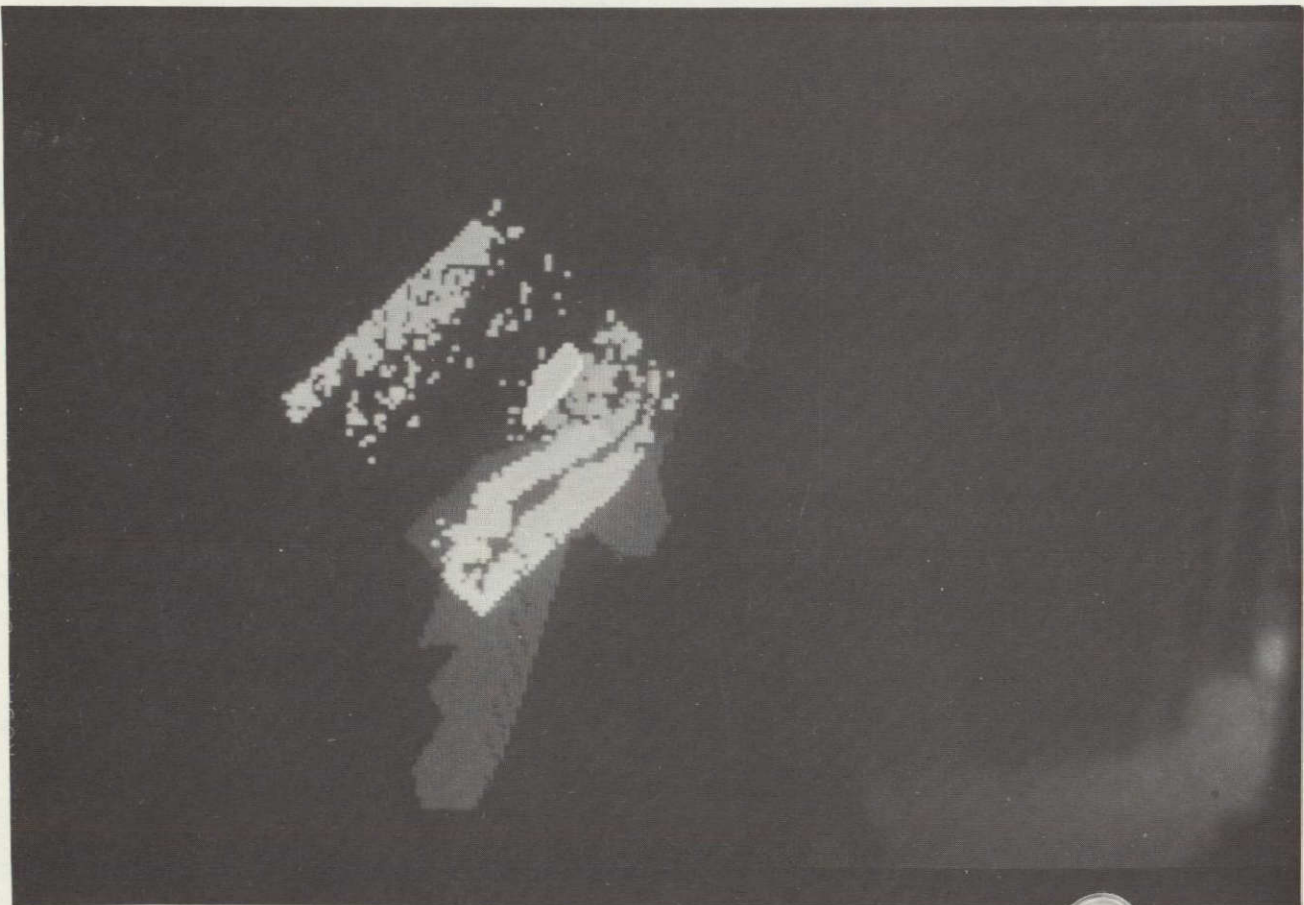


Figure 7. Landsat and Basin Overlay

TOPOGRAPHIC DATA

The importance of topographic data to hydrology investigations is obvious. Snow melt and precipitation runoff come immediately to mind. Digital topographic data for much of the United States are available from the National Cartographic Information Center (NCIC) at a 1:250,000 scale. Elevation values are taken every 0.01 inch at this 1:250,000 scale. This corresponds to 63-meter intervals on the ground.

In this next display digital topographic data for a portion of the Bear River area have been converted to image format. The area shown is approximately 20 x 20 miles. North is to the left here due to the NCIC data format. Elevations in this area range up to 10,000 feet. The dark areas are low elevation and the bright areas are high elevation. We are working with 256 intensity levels which corresponds to 39-foot elevation steps per level.

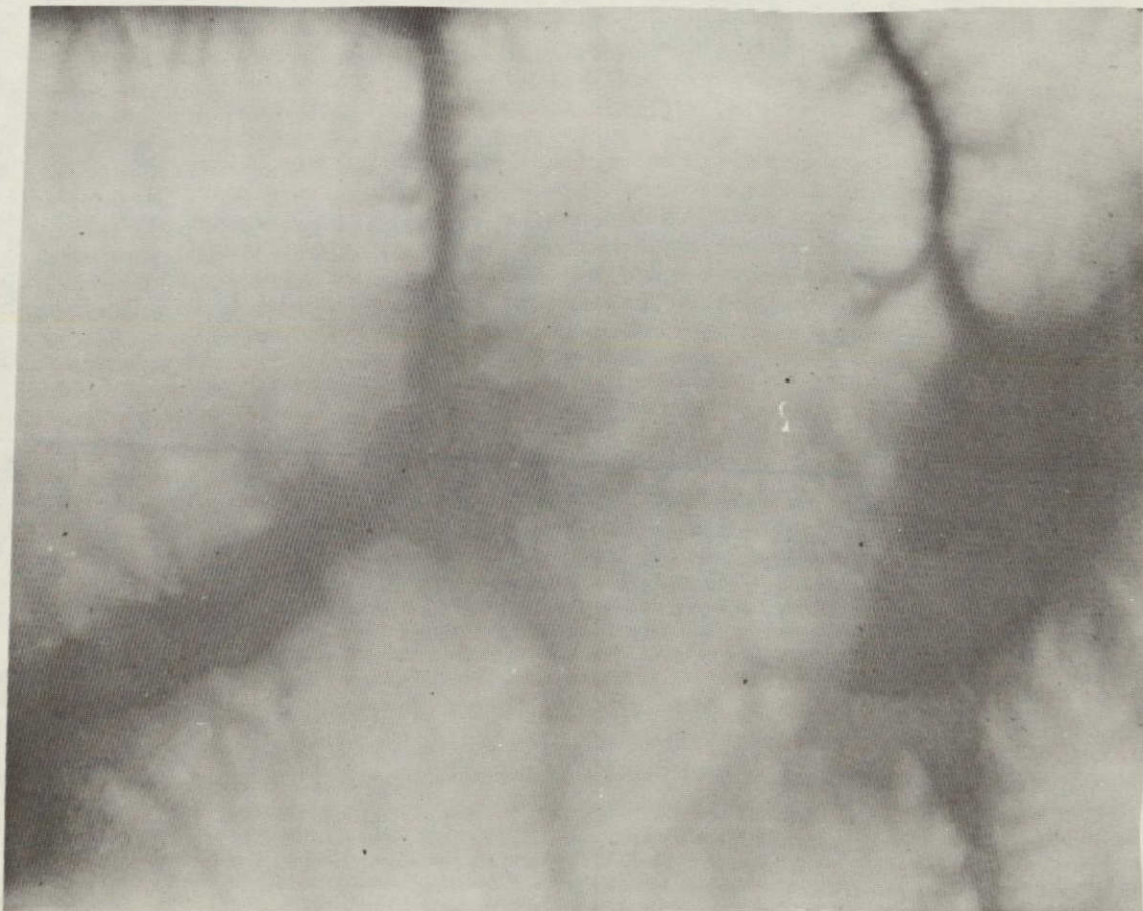


Figure 8. Topographic Data

CONTOUR REGIONS

The Data Management System contains image processing software to expand or reduce image size, adjust contrast, enhance edges, and geometrically adjust images. The contrast of the topographic image is shown here broken into eight ranges corresponding to approximately 1,200-foot elevation intervals. This has the effect of contouring the data.

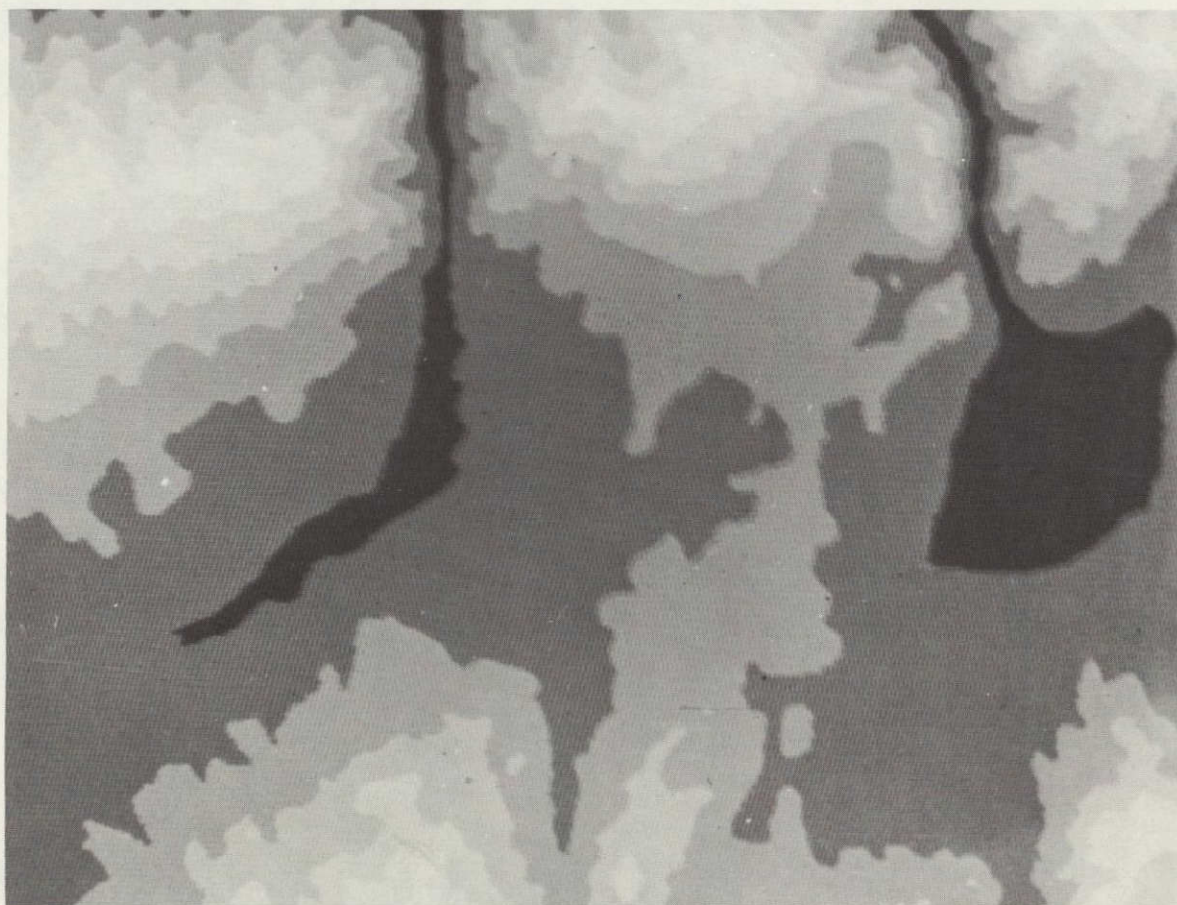


Figure 9. Contour Regions

CONTOUR BOUNDARIES

Next, the edge enhancement routine is used to form lines at the contour boundaries, as shown in this display.

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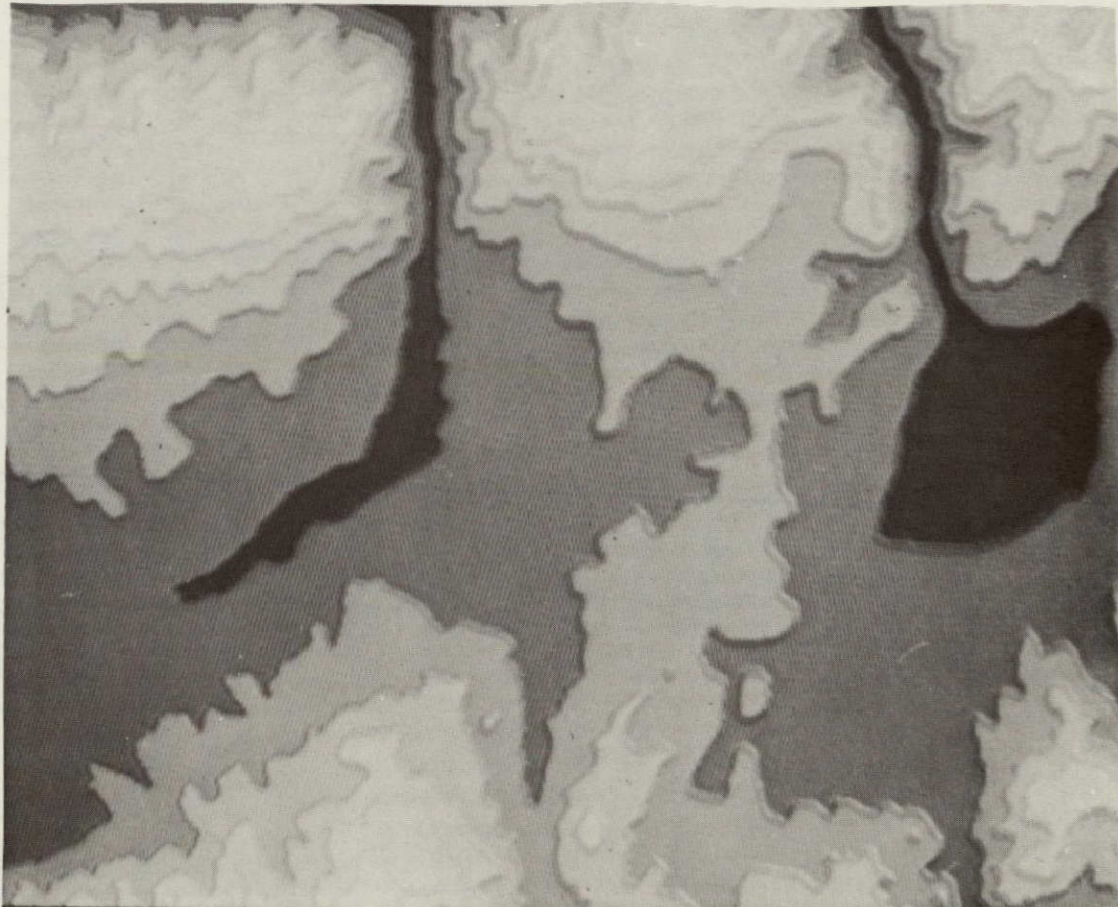


Figure 10. Contour Boundaries

SUPERIMPOSED TOPOGRAPHIC IMAGE

The contour lines can then be superimposed on the original topographic image to allow the user to follow along equal elevation levels.

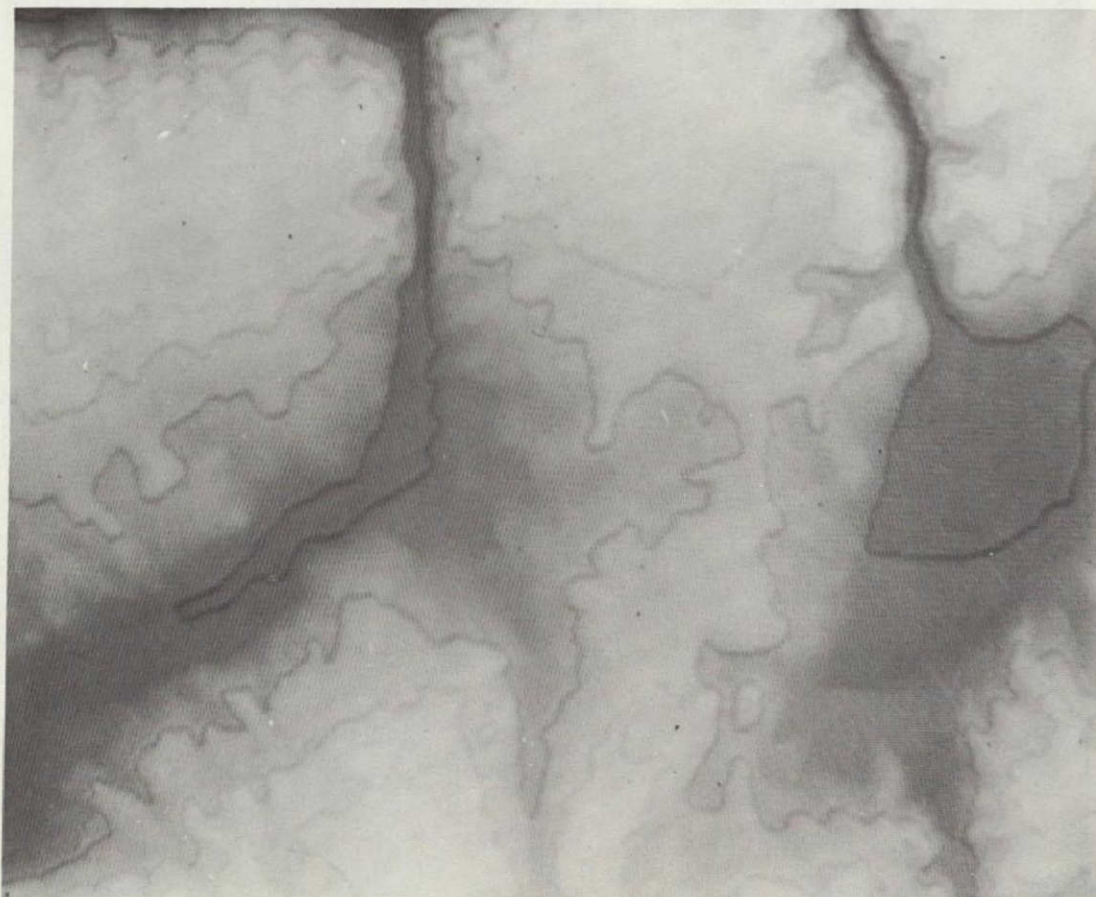


Figure 11. Superimposed Topographic Image

PERSPECTIVE VIEW

The final representation of topographic data is a perspective view. The perspective program allows a 50 x 50 point area to be shown. In order to cover a suitable ground area in 50 x 50 points we first reduce the 63-meter resolution topographic image to 252-meter resolutions. This reduction is accomplished by two passes of the 2:1 reduction program.

Now the cursor is used to select the 50 x 50 subregion to be viewed. This subregion is slightly over 12 x 12 km. The area we have selected here is Ogden Canyon since it is an area of rapid elevation change. The perspective display is done on Tektronix scope since it has higher resolution than the color CRT and is better suited to line graphic displays.

The hydrologist can use this capability to gain a visual feel for the terrain in his study area. Hard copies of the Tektronix display are also possible.

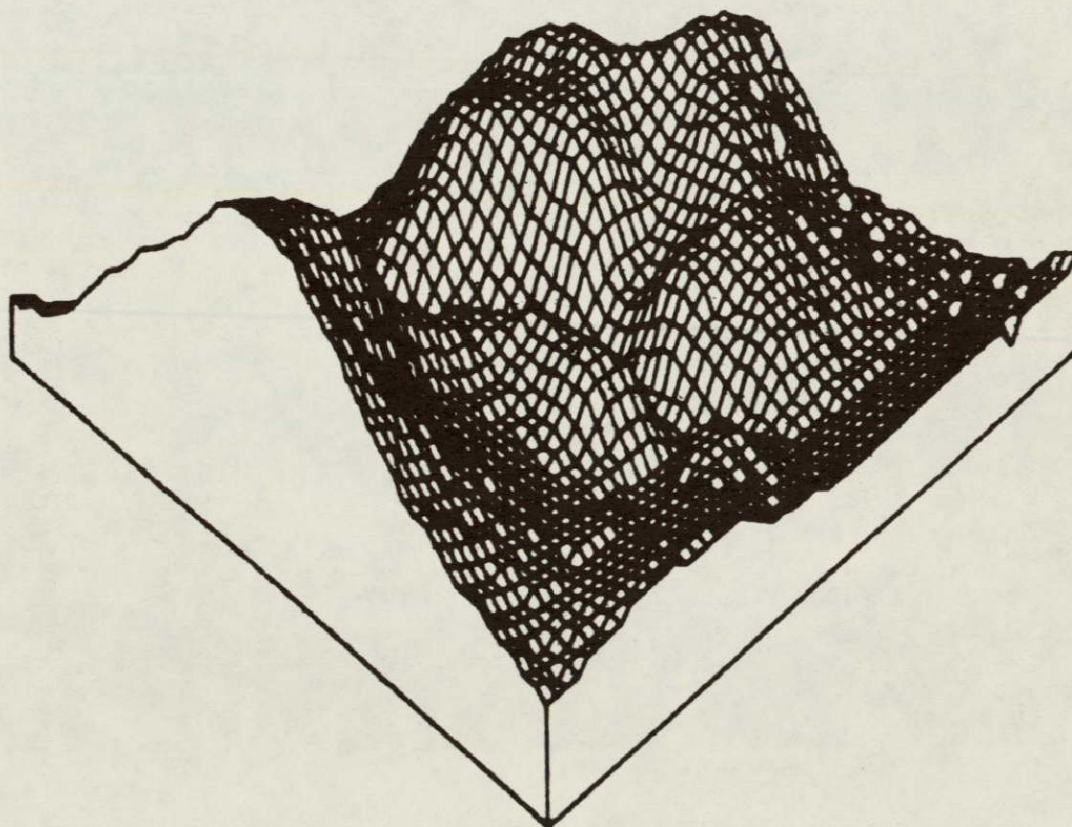


Figure 12. Perspective View

SMS IMAGE

The last type of data to be demonstrated is SMS imagery. Here we have a portion of an SMS scene over the Bear River, Salt Lake area. Clouds obscure a large portion of the image area and Salt Lake and Bear Lake can just barely be seen.

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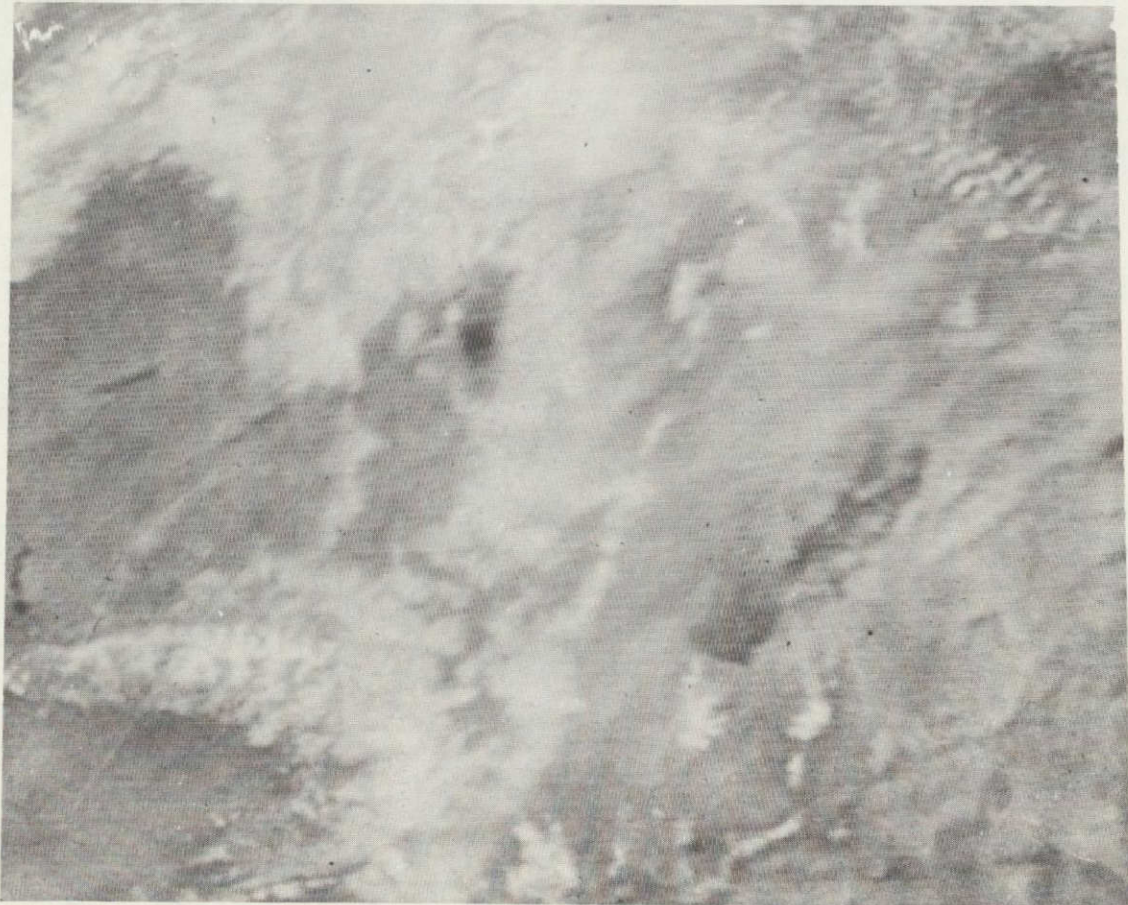


Figure 13. SMS Image

PRECIPITATION MAP

The Water Resources Data Management System allows users to scribe polygons about clouds. Seven cloud types can be identified in SMS visible imagery and three are precipitation bearing.

Precipitation Bearing

- (1) Cumulonimbus
- (2) Nimbostratus
- (3) Cumulus congestus

Non-Precipitation Bearing

- (4) Stratocumulus
- (5) Stratus
- (6) Cumulus
- (7) Cirrus

Once the cloud type is identified to the Data Management System it computes an expected precipitation estimate in millimeters per 6 hours. This information forms a precipitation map which can be entered in the daily data base.

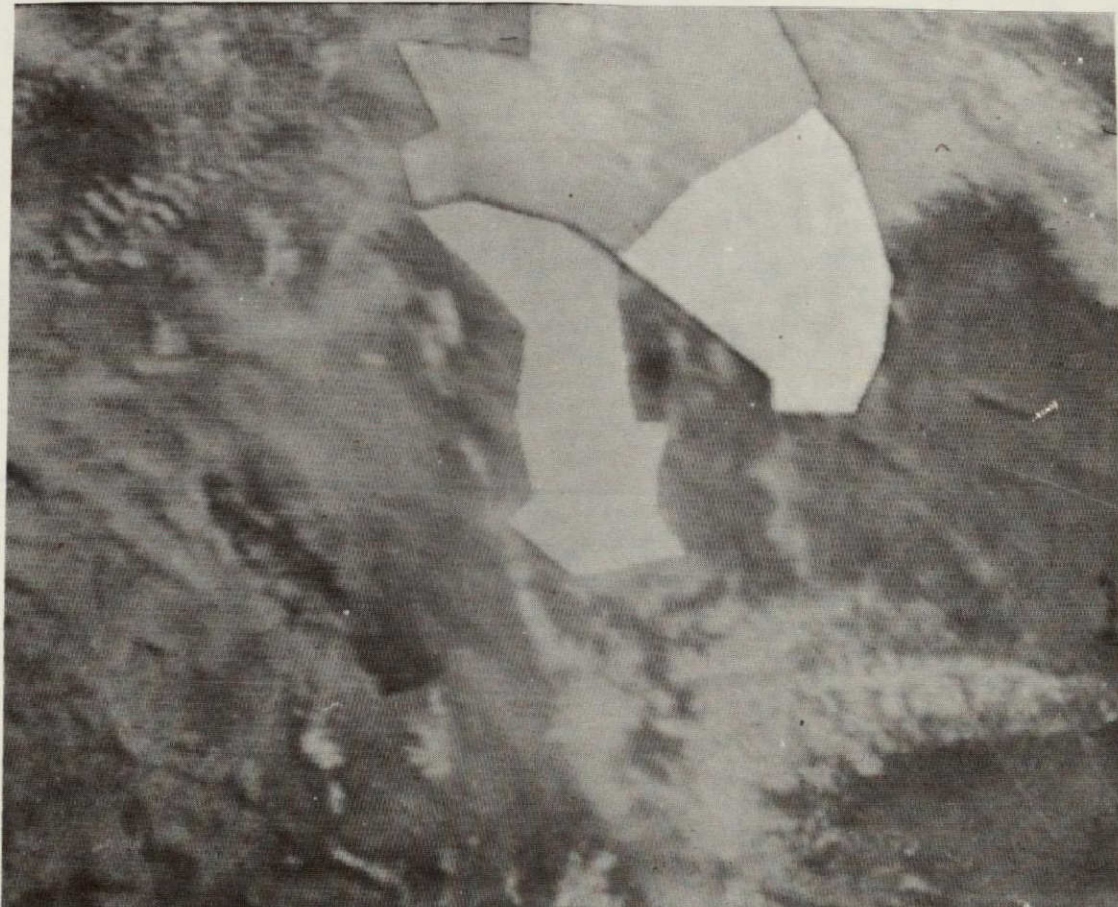


Figure 14. Precipitation Map

CONCLUSIONS

To summarize - we have a prototype system for processing, displaying and storing data of interest to hydrologists. We are currently involved in an effort to expand this system to have it interface the National Weather Service River Forecast System which is a hydrology modelling system.

The cell-level data will be aggregated up to the subbasin level and used to drive the model. We hope to show that satellite remote sensing data can be used to replace or supplement conventional hydrology model input parameters.

